Enhancement of Spectrum Sensing techniques in Cognitive Radio

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna International Institute of Research and Studies
(Deemed to be University)

by

Neha Chaudhary
Registration number: 16/Ph.D/033

Under the supervision of

Dr. Rashima Mahajan
Associate Professor, FET, MRIIRS

FACULTY OF ENGINEERING & TECHNOLOGY

MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH & STUDIES

SECTOR-43, SURAJKUND –DELHI ROAD, FARIDABAD – 121001

FACULTY OF ENGINEERING & TECHNOLOGY

CERTIFICATE

I hereby declare that the short synopsis "Enhancement of Spectrum Sensing Techniques in Cognitive Radio "being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Electronics & Communication Engineering under faculty of Engineering & Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2019-2020.

It is a bona fide record of original work carried out under the supervision of Dr. Rashima Mahajan .The work has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

(Neha Chaudhary)
Reg No:16/Ph.D/033

Signature of the Supervisor
Dr. Rashima Mahajan
Associate Professor, CSE Department, FET, MRIIRS

(Chairman, DRC)

Chairperson, CDP

ABSTRACT

Cognitive radio networks are implemented to increase the access of available radio spectrum by addressing the later's limitation of spectrum scarcity. Utilization of available spectrum can be improved by enhanced the spectrum sensing techniques. Spectrum sensing phenomenon is used to estimate the unutilized frequency band of whole radio spectrum. The performance of available spectrum sensing techniques may degrade substantially in low signal to noise ratio, multipath fading & shadowing environments. This may lead to increase in probability of False Alarm (ratio of number of false alarm to number of trials), minimum probability of actual detection (ratio of number of detection to number of trails) and misdetection hidden terminal. An attempt shall be made to cater these limitations by using dynamic selection of threshold and efficient power spectral estimation techniques for spectrum sensing. The primary aim shall be to implement a energy detection based transmitter section. A more efficient primary signal detection technique shall be developed by comparing selected threshold with the computed energy level of the signal. This shall be followed by determination of unused frequency bands .The performance of the developed technique shall be evaluated using signal to noise ratio, probability of actual detection (Pa) and probability of false alarm rate (Pf). The outcome of the research work shall lead to enhance the reliability and quality of communication networks by effective utilization of spectrum resources.

Key words: Cognitive Radio, Spectrum Sensing Techniques, Energy Detector, Signal to Noise Ratio, Probability of Actual Detection, Probability of False Alarm Rate.

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1. INTRODUCTION

Today's advancement in technology, growth in population and subsequent wireless applications are the primary reasons for increased demand of spectrum. The survey report by Federal Communications Commission indicates that some of the frequency bands of radio frequency spectrum are not utilized or partially utilized leading to spectrum scarcity. The reason cited for this is the use of conventional access. To overcome above issues, a new spectrum access technology called DSA (Dynamic Spectrum Access) also known as Cognitive Radio (CR) technology was introduced. In this technique, transceiver has intelligence to sense, analyze, observe, learn and adapt to the environmental conditions by which it can distinguish between used and unused communication channels. Also, it instantly tunes to unused bands ensuring better optimization of the available RF spectrum and minimizing congestion or interference. Dynamic spectrum access users can be categorized as primary users (high priority users) and secondary users. Primary user are the ones to whom the spectrum band is allocated by the Government bodies. They have full access to allocated band as and when required. Secondary Users (Low Priority Users) are the ones who are permitted to use the frequency spectrum momentarily ensuring no interference with the high priority users. The combination of primary and secondary user, wherein primary user senses an idle spectrum and secondary user utilizes the spectrum temporarily ensuring that there is no interference with the former, are the cause for success of the cognitive radio technology. The two categories of cognitive radio are full cognitive radio and spectrum sensing CR. In the full cognitive radio wireless network will consider every single possible parameter whereas spectrum sensing cognitive radio considered only radio frequency spectrum.

Cognitive radio has main two parameters .One is their cognitive capabilities, which define the capability to observe the environment to subsequently create, plan and orient itself. The other is re-configurability property, which defines capability of cognitive radio to be programmed with dynamism for each range of the radio environment. Figure 1 shows the four fundamental functions of cognitive radio. One is spectrum sensing, at this stage, cognitive radio continuously monitors the radio environment and geographically detects possible free frequency band.

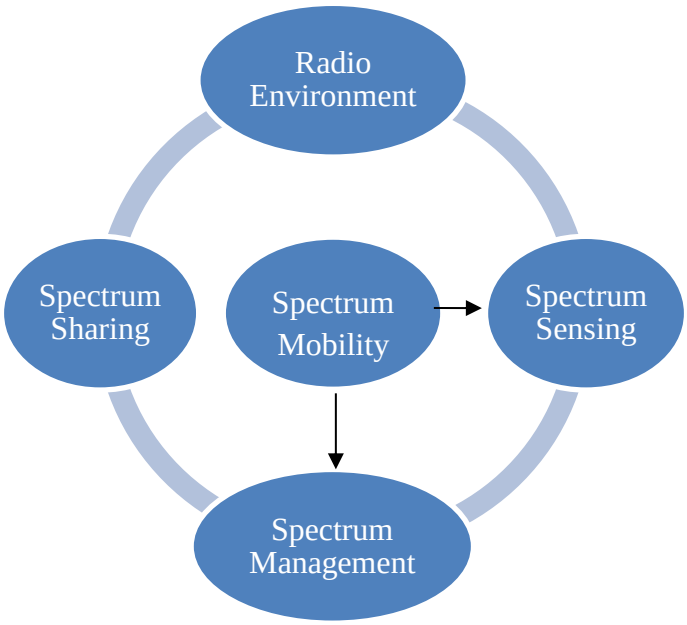

Figure1: Functions of Cognitive Radio

This is followed by spectrum decision, i.e. when to start its operations. For this cognitive radio, might use data from authorized policies and databases to improve the operations. The next is spectrum sharing, it can be performed by two methods, underlay and overlay. In underlay method of spectrum sharing, level of noise and interference is below the threshold values. In the overlay method, the unlicensed users share the frequency band which is already engaged by the licensed user. The last is spectrum mobility, in this case cognitive radio vacates the channel if the primary/licensed user is detected. This research work will be focused on implementation of more efficient spectrum sensing technique.

Spectrum sensing techniques are classified into three main categories viz, transmitter detection, wideband spectrum sensing and null space-based cognitive radio. Transmitter detection techniques are further grouped in to matched- filter detection, blind detection/energy detection and cyclostationary detection technique. Energy/blind detection technique provides the information of absence or presence of signal just by measuring the value of energy level in the received signal. In cyclostationary technique, different signal modulation techniques like binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), amplitude modulation (AM) and orthogonal frequency division multiplexing (OFDM) were introduced because of their cyclostationary feature. For large spectral bandwidths in MHz or GHz range wideband spectrum sensing techniques are introduced.

Cooperative/Transmitter detection and interference based detection are two main classifications of wideband spectrum technique. In null based technique, multiple antennas are used to find out the null space to transmit the signal with minimum effect of interference. The details of these spectrum sensing techniques are provided in section 3 that deals with description of broad topic. The next section describes the detailed literature of the selected research topic.

2. LITERATURE REVIEW

Literature presents numerous spectrum sensing techniques and their implementations. Many of the researchers discussed about the need of spectrum sensing and various methods to enhance the spectrum sensing so that utilization of available spectrum can be improved. Multiple wireless services need to share radio spectrum. Careful planning and management could maximize the well-organized use of radio spectrum environment. The National regulatory agency has issued the radio spectrum to the individual users. For commercial or public interest, frequency bands are already licensed. Demand of wireless communication services is continuously increasing. This further increases the requirement of radio spectrum. To solve the problem of underutilization of the allocated spectrum and spectrum allocation congestion, cognitive radio approach has been proposed (Mitola, 2000). In radio frequency environment cognitive radio is fully re-configurable and cognitively adapts itself to the communication environment. Wang and Liu (2011) introduced that cognitive radio do opportunistic spectrum access. The purpose of cognitive radio is effectively used the radio spectrum with less interference with the licensed user. While determination of primary receiver many issues has been faced i.e. Interference, hidden node detection problem, spectrum sharing at vertical and horizontal sections. Basic three on-line tasks of cognitive radio have been introduced in the literature (Haykin, 2005). First is Radio Scene Analysis which consists of finding the available spectrum holes and in radio environment calculate the interference temperature (availability of RF power at receiving antenna to amount of power delivered to a receiver). Second is Channel Identification, which provides the idea about the capacity of channel available at transmitter. Last task is dynamic control of power transmission and management of Spectrum. Different aspects are considered within the field to obtain a optimal system. It includes spectrum hole identification, spectrum management,

sharing and mobility of spectrum. During spectrum sensing process, cognitive radio detects the unutilized frequency band by the licensed/primary users. After sensing, spectrum management and other functions are introduced. Shaikh and Gupta (2014) explained that spectrum sensing techniques are classified as cooperative, non cooperative and interference based sensing. By using numerous cognitive sensors the cooperative sensing can raise the strength of the network. Feasible implementation can achieve by using radio –frequency front–end and Analog/Digital converter (Cabric, Mishra and Brodersen, 2004). Detection of primary user and radio sensitivity can be improved by using digital signal processing based techniques. Due to fading and shadowing reliable detection of licensed users is difficult in case of individual sensing. Probability of interference for high priority users can be minimized by cooperative decision making. In wireless channel, phase and amplitude of signal may change with the effect of fading. Different fading models like Rayleigh, Nakagami-n, Rice and lognormal have been introduced for analyzing the behaviour of spectrum sensing techniques. In case of lognormal fading, energy detector provided better performance for different ranges of signal to noise ratio (Fabrício, Carvalho, Waslon, Marcelo and Alencar, 2015) .Coordination in sensing is very important factor for accurate sensing, however in the absence of time synchronization, coordination would be very difficult to achieve at the MAC (Medium access control) layer (Cormio and Chowdhury, 2009). Exchange of information from several CR users may be integrated, that's why sensing information dissemination is also very important in the sensing. At MAC layer by using efficient power control techniques, adaptive modulation and maintaing trade –off between actual transmission time & allocated time, more efficient sensing could be achieved while maintaing quality of service requirement to prevent performance degradation.

Security is also a concerned area due to cognitive characteristics. (Li, Feng, Wei, Feng and Zhang, 2014) provides the mechanism of noval penalty which gave the solution of security threat. This includes trust value collection, process of authentication, configuration by interactive sessions, and storage of data. By making cluster heads and fusion of the data hierarchical architecture of cognitive radio could managed.

Hardware and energy constraints are the shortcomings to sense the spectrum simultaneously (Pandit and Singh, 2017). For efficient transmission, there must be sensing synchronization between various cognitive radios. If the availability of spectral information leads to efficient

recognition of spectrum hole in the area of a receiver, then better utilization of radio spectrum could take place. Interwave, underlay and overlay are the three models used in cognitive radio networks. In interwave type, unlicenced users could not access the occupied band. On the other hand, in underlay sharing mechanism could take place by licenced and unlicenced users. Next, in overlay concurrently transmission could be done by primary and secondary user. Depending upon the size of bandwidth, a narrowband and wideband are two broad classification of spectrum sensing. Narrowband dynamic technique uses frequency hopping for sensing and quiet period approaches for monitoring actions. Wideband techniques are categorized into nyquist and subnyquist sensing techniques (Ali and Hamouda, 2016).

As discussed in introduction section, on the basis of signal detection spectrum sensing techniques are classified as transmitter detection/signal detection sensing techniques are those in which position of licensed user is not known and no communication exists between the different secondary users. Matched filtering, energy detector, cyclostationary detection are the subcategories of transmitter detection technique. Co-operative sensing techniques are those in which the communication between the different secondary users takes place to give the decisions. Multipath fading effects, shadowing and penetrations due to buildings are the reasons that affect primary signal detection. Interference based sensing technique are used to specify and manage interference at the receiver interference temperature model. Maximization in SNR can be achieved by matched filter detection. Detection of licensed user by the matched filter is also called the optimum method where information of the transmitted signal is already present (Gette and Motta, 2015). Time required for sensing false alarm and missed detection are minimum in this method. Energy detector is another method of spectrum sensing with low implementation and computational complexity. This method doesn't require prior information of the licensed user. Waveform based sensing can be achieved by the knowledge of signal patterns and correlating received signal with well-known replica of itself. Different models of spectrum sensing have been introduced for different techniques (Salahdine, 2017). Model of spectrum sensing consist is based on following function as stated in equation (1).

$$y(n) = \begin{cases} w(n), & H0 : \text{PU Absent} \\ h * s(n) + w(n) & H1 : \text{PU Present} \end{cases} \quad \dots (1)$$

y(n) represents secondary/low priority user's received signal. Primary/high priority user signal would be represented by s(n), w(n) represents the additive white Gaussian noise (AWGN) with zero mean, h is the channel gain. H0 shows absence of primary/high priority signal and H1 indicates presence of primary/high priority user signal. Decision will take place by using two hypotheses H0 and H1.Comparison of detector output with threshold gives the presence/absence of primary/licensed user. The relation used for sensing decision is described in equation (2).

$$\begin{cases} if\ T \geq \gamma, H1 \\ if\ T < \gamma, H0 \end{cases} \quad \ldots\ldots (2)$$

The output of the detector is represented by T while γ denotes the sensing threshold.

Figure 2 represents general spectrum sensing model.

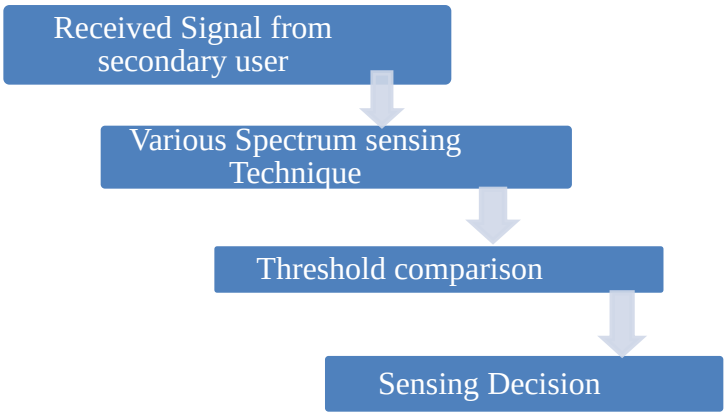

Figure 2: Spectrum Sensing Model Representation

Spectrum sensing concepts could be re-evaluated by considering the different dimensions like frequency, time, code, angle and geographical space (Yucek and Arslan, 2009). Energy detector based sensing can be summarized by the two probabilities functions. One is detection probability and second is false alarm rate. Performances at diverse level of threshold can be obtained by using receiver operating characteristic curves Noise variance is the important factor for threshold value of energy detector. Performance loss can occur by small noise error transmission. (Ohta ,Takyu , Fujii and Taromaru, 2016) developed two stage fast Fourier Transform (FFT) based energy detection techniques. For single transceiver, myopic approach has been used and the online learning algorithm provides idea about which channel should be selected. Also FET based energy detector technique used

window function. The function of window function is to reduce the correlation among the frames By adaptive value of threshold seamless vacation of secondary users could takes place and optimal frame detection satisfied the demand of throughput (Ahmed, Salam, Ray, Saleh, Araji, Mezher and Nasir (2019). Indrakanti and Elias (2019) introduced that performance of hardware complexity and less sensing time could be achieved by using farrow structure (design based on variable bandwidth and magnitude of filter) with variable bandwidth. Instead of using variable filter coefficients, constant values can be used to reduce complexity. Due to the cyclic prefix some of the bandwidth could be wasted. For orthogonal frequency division multiplexing, by inserting filter at transmitter and receiver better utilization of bandwidth could take place (Kumar and Kumar, 2019).Noise uncertainty problem have been reduced by using two sensing algorithms. First considered ratio of maximum to minimum eigen-value and second considered ratio of average eigen-value to min eigen-value (Zeng and liang, 2009).In autonomous compressive sensing technique, secondary users select minimum sensing time which may lead to improved detection rate (Zhang, Ma, Gao and Zhang,2018). Different power spectral density techniques at variable frequencies have been implemented to improve signal detection rates (Hossain and Kawsar , 2013).Calculation of degree of trustworthiness by using Dempster Shafer theory for cooperative spectrum sensing technique were introduced (Wang, Feng, Wu, Zheng, Xu and Ding, 2014). Numerous IEEE802.22 standard based approaches for cooperative spectrum sensing were introduced and simulations were carried out for single secondary user unit and for multiple secondary users. Perception learning model has been used for analyzing cooperative sensing scheme. Periodram approach was used for signal power estimation. Accuracy and performance evaluation of the proposed algorithms could be calculated by performance metrics i.e detection probability and false alarm rate (Balaji, Kabra, Saieesh, Hota and Raghurama, 2015).With minimum amount of energy utilization the efficiency of cognitive radio network could be achieved. By applying one-bit for acknowledgement process overhead will reduce prominently which will not be possible by using two decision bit (Chaudhary, Dongre and Patil, 2016).

Spectrum sensing performance will degrade with the effect of malicious users. Cluster to licenced users distance could be estimated by maximum likelihood technique. Trustful cluster could be achieved by comparison with preset threshold. Robustness and high

detection rate could be achievable by using trustful cluster (Yubao, 2018).Overhead during sensing could be minimized by using joint optimal model. Its first step includes listen following by transmission process. Polyblock algorithm has been introduced which improved the total throughput of the system significantly (Liu and Jia, 2017).Cooperative sensing is considered as the best method for improvement of accuracy. Reliability of the node can be achieved by using value i.e called belief level. First the division of sensing nodes is done into various clusters. For each cluster cluster, head is assigned and the function of cluster heads is to collect the report of sensing from various cognitive nodes (Khasawneh and Agarwal, 2016).

A detailed literature analysis revealed that available radio spectrum is not utilized properly. Cognitive radio technology could enhance the efficiency of spectrum by continuously monitoring radio environment and fill the gap of the frequency bands automatically. Detailed review of various spectrum sensing techniques has been provided. Each technique has some advantages and disadvantages. Design and selection of technique is dependent on the type of application and user system. Thus, spectrum sensing is still the open research area and by using the library of different sensing algorithms, probability of opportunity detection can be enhanced.

2.1 Gaps in Literature

Following gaps are found in the literature.

1. Underutilization of the electromagnetic spectrum
2. Performance in spectrum sensing is restricted by noise uncertainty, multi-path fading and shadowing effect.
3. Most of spectrum sensing technique possesses high signal detection time.
4. Spectrum sensing performance degrades in low SNR region.
5. High false alarm probability and missed detection probability rates in existing spectrum sensing techniques.

3. DESCRIPTION OF TOPIC

Spectrum sensing is key factor for cognitive radio. For available radio spectrum, spectrum sensing can find out unused portion of frequency band with minimum interference. First it consists of sensing of the spectrum hole i.e. the frequency bands which are not in use. Next, is to find the wavelength interval of channel, determination of angle of arrival of an interfering signal and classification of signals. Primary/licensed can use the available frequency band of the spectrum and other is unlicensed user (Secondary user) who has the lower priority but these users continuously monitor the primary user to find the unused spectrum. This phenomenon is known as spectrum sensing (Mehta, Kumar and Saini, 2013). Numerous spectrum sensing techniques are used to find unutilized spectrum. Classification of spectrum sensing techniques are shown in figure 3 .Transmitter detection/Non coherent schemes is to find the primary transmitter signals and use general observations but hidden node detection could not take place. One of the classifications of spectrum sensing techniques is energy detector which is also called the blind signal detection. That provides the information weather signal is present or not by comparison of input signal with threshold signal. In matched filter detection unlicensed user has prior information of licensed user signal and use correlation function. Matched filter technique required less detection time. Cyclostationary sensing method exhibits the features of spectral correlation and periodic statistics. High sensing time and more computational complexity are the disadvantages of these techniques (Sindhu and Singh, 2017). The limitations of transmitter detection techniques are overcome by cooperative spectrum strategies. In this technique sensing information will be shared with the other cognitive users. Depending upon the level of cooperation, these sensing techniques are classified into centralized, decentralized and hybrid spectrum sensing techniques. Radio identification technique is based on a number of extracted features like modulation techniques, frequency during transmission, and transmission range. Covariance method has been used the covariance matrix. Hence each technique has their own advantage and disadvantage (Amrutha and Karthikeyan, 2017). That's why two-stage type of spectrum sensing models or hybrid detection method are effectively used, in which first stage can use one type of spectrum sensing technique and second stage follow other sensing technique (Lai, Peng, Yang and Zhou, 2015).

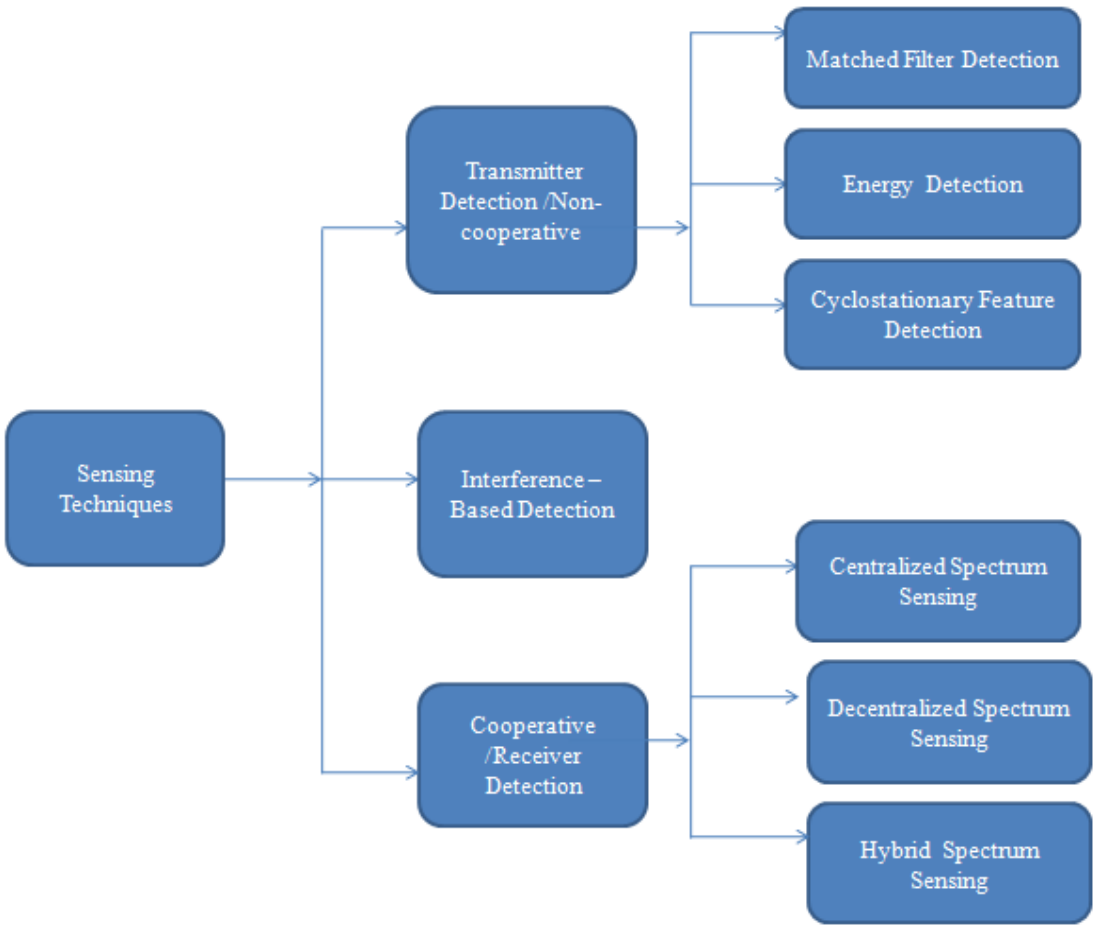

Figure 3: Categorization of spectrum sensing techniques

Performance of various schemes is evaluated by different parameters like probability of detection and false alarm probability. By using various spectrums sensing technique we would achieve accuracy, efficiency and less sensing time while operation process. Sensing time of matched filter is very high. Also complexity, robustness against SNR, detection performance is very high (Arjoune, Mrabet, Ghazi and Tamtaoui, 2018) .In case of energy detector sensing time low also, complexity, robustness against signal to noise ratio and detection performance also very low. That's why most popular technology is energy detector which do not required the characterization of primary signal and provides enhanced energy detector technique by considered dynamic value of the threshold. By using discrete Fourier transform for the dynamic threshold selection spectrum sensing, value of error in the noisy environment could be minimized (joshi, popescu and dobre, 2010).Image binarization technique introduced for selection of adaptive threshold. Estimation of threshold by this method consists of previous iteration decision, SNR, number of samples, detection and false

alarm rate probability (Muralidharan,Venkateswaran, Ajay, Prakash, Arora and Kirthiga, 2015). Some of the algorithm based on double threshold instead of single threshold. One threshold will indicate the free available spectrum and other threshold will indicate occupied band (Sarker 2015). Value of threshold can be calculated by constant value of false alarm rate. In this type of cases value of noise directly add in to the signal for implementation process and in this method noise can be calculated by eigenvalue, marcenko paster density and empirical distribution function (Plata and Reatiga, 2012). Energy detector methods were based on the correction of conventional principal component analysis (PCA). By applying this method for wide range of SNR, probability of false alarm can be calculated (Rao,Mazumdar and Kadambi,2015). Estimated the value of noise from eigen-values and received signals covariance. So various author provides lot of research work on energy detector.

4. OBJECTIVES OF RESEARCH

4.1 Problem Statement Formulation:

Literature review reveals that, RF spectrum is getting crowded due to increased demand of wireless applications. The flexible, efficient and reliable utilization of available spectrum is need of the hour.

The problem of proposed research is to implement sensing technique for better utilization of radio spectrum with improved signal to noise ratio, minimum value of artificial alarm rate and maximum possibility of actual detection with reduced system complexity.

4.2 Objectives of the research shall be:

- To explore different spectrum sensing techniques.
- To implement primary transmitter section by using modulated signal and noise in MATLAB.
- To develop an algorithm for improved primary signal detection with reduced computational complexity
- To determine unused frequency bands for better utilization of available spectrum.

- To evaluate performance of developed sensing technique by using different parameters like false alarm rate (Pf), actual detection probability (Pd) and signal to noise ratio.
- To develop hybrid spectrum sensing detection techniques.

5. METHODOLOGY

The proposed methodology firstly includes the implementation of transmitter section. After that implementation of efficient energy detection technique will takes place. An efficient energy detection technique shall be implemented to detect the primary signal. The second phase will include the determination of unused frequency bands. The performance of implemented technique shall be evaluated by using different parameters like false alarm rate (Pf), actual detection probability (Pd) and signal to noise ratio. The flowchart of proposed methodology is presented in Figure 4.

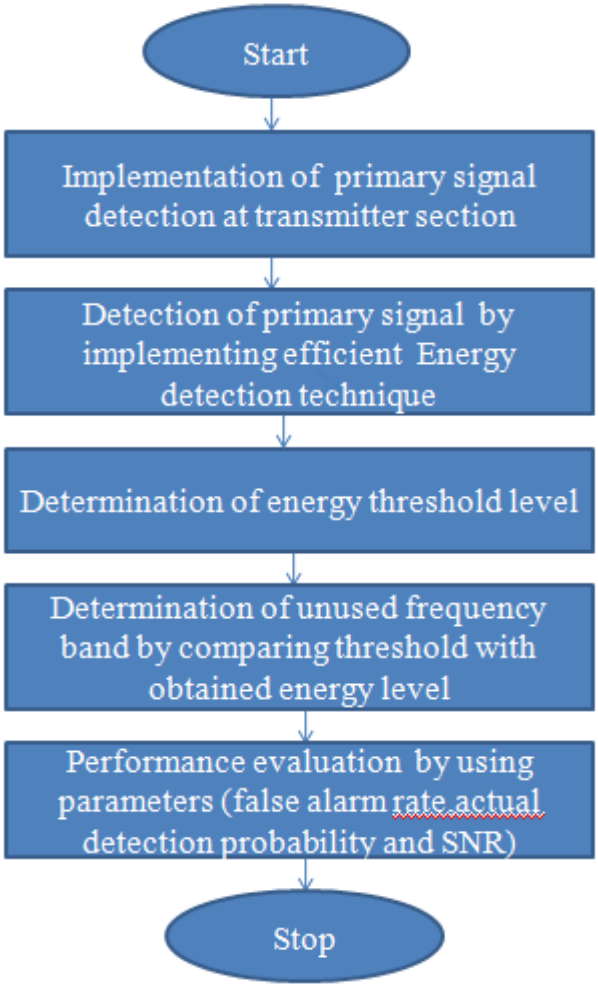
Start
Implementation of primary signal detection at transmitter section
Detection of primary signal by implementing efficient Energy detection technique
Determination of energy threshold level
Determination of unused frequency band by comparing threshold with obtained energy level
Performance evaluation by using parameters (false alarm rate actual detection probability and SNR)
Stop

Figure 4: Methodology

Step (1): Implementation of transmitter section will take place by selecting the appropriate input signal .The noise signal (Gaussian /random) will be added to the selected input signal.. The selected signal will be modulated by selecting appropriate modulation technique viz, phase, binary, quadrature shift keying.

Step (2): Power spectral density can be estimated by parametric, non-parametric and subspace methods. If the power spectral estimation is calculated by signal itself then it will be the nonparametric power spectrum estimation techniques. The Periodogram, Welch's and Multi-taper are the categories of non-parametric type. If the linear system output is driven by white noise then power will be estimated by using parametric approach. Examples of parametric approach are Yule-Walker autoregressive and Burg method. The primary transmitter shall be detected by implementing a more efficient energy detection technique. The power spectral density methods shall be explored to improve its performance. These methods first calculate the coefficients of the linear system then generate the signal hypothetically. When the input signal is of short duration, parametric methods, provide better results compared to non-parametric methods. Super –resolution (high resolution) methods will be used for low SNR and for sinusoidal signals which is buried with noise. Multiple signal classification and eigenvector are the example of subspace category.

Step (3): Threshold level will be calculated dynamic approach rather than static one. Static approach depends upon the threshold factor, number of samples and signals to noise ratio. Dynamic threshold will be calculated here by considering the noise variance, samples value and false alarm rate. The estimation of threshold will be done depending upon previous iteration decision and targeted probability of detection .The double threshold algorithm shall also be explored for better results.

Step (4): By calculating threshold and energy of the signal, location of primary signal will be estimated. If value of threshold will be greater than the estimated energy then it shows the absence of primary/high priority/licensed signal and if value of threshold is less then, it indicates the presence of the primary/licensed/high priority signal.

Step (5): Performance of developed algorithm will be evaluated by using parameters like actual detection (Pd) and false alarm rate probability (Pf).

Probability of detection (Pd) indicated the actual detection of primary user present over the samples.

Probability of false alarm (Pf) indicates the value of missed detection over the samples.

The emphasis shall be to maximize the actual detection probability (Pd) by minimizing the false alarm rate (Pf) over different SNR.

6. EXPECTED OUTCOME OF RESEARCH

1. A spectrum sensing algorithm with minimized false alarm rate, high actual detection probability with higher SNR and reduced complexity.

2. More efficient hybrid spectrum sensing algorithm for better utilization of radio spectrum.

7. PROPOSED TIME FRAME

TIME FRAME	JAN-JUN 2017	JULY-DEC 2017	JAN-JUN 2018	JULY-DEC 2018	JAN-JUN 2019	JULY-DEC 2019	JAN- JUN 2020	JULY-DEC 2020
Course work								
Extensive literature survey								
Problem statement formulation								
Publication On literature Survey								
Implement Spectrum Sensing techniques by using MATLAB								
Develop improved Spectrum sensing technique								
Publication on improved spectrun sensing technique								
Develop an algorithm for improving primary signal detection with reduced computational complexity								
Publication on obtained result								
Thesis submission								

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Submission date: 18-Sep-2019 04:16PM (UTC+0530)
Submission ID: 1175042028
File name: short_synopsis_Neha_Chaudhary_sep17,2019.docx (139.73K)
Word count: 5334
Character count: 32316

Enhancement of Spectrum Sensing techniques in Cognitive Radio

SHORT SYNOPSIS

Neha Chaudhary
Registration number 16/Ph.D/033

Under the supervision of

Dr. Rashima Mahajan

ABSTRACT

Cognitive radio networks are implemented to increase the access of available radio spectrum by addressing the later's limitation of spectrum scarcity. Spectrum sensing phenomenon is used to estimate the unutilized frequency band of whole radio spectrum. The performance of available spectrum sensing techniques may degrade substantially in low signal to noise ratio, multipath fading & shadowing environments. This may lead to maximum recognition of false alarm (ratio of number of false alarm to number of trials), minimum probability of actual detection(ratio of number of detection to number of trails),hidden terminal detection etc. An attempt shall be made to cater these limitations by using dynamic selection of threshold and efficient power spectral estimation techniques. The primary aim shall be to implement a energy detection based transmitter section .A more efficient primary signal detection techniques shall be developed by comparing selected threshold with the computed energy level of the signal. This shall be followed by determination of unused frequency bands .The performance of the developed technique shall be evaluated using signal to noise ratio, probability of actual detection (Pa) and probability of false alarm rate (Pf). So reliability and quality of communication networks shall be enhanced by effective utilization of spectrum resources.

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